Electronic Supplementary Material (ESI) for Organic & Biomolecular Chemistry.

Supplementary Information

Synthesis of planar chiral [2.2]paracyclophane-based bisoxazoline ligands bearing no central chirality and application to Cu-catalyzed asymmetric O-H insertion reaction

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General Method. Melting points were measured with YANAGIMOTO micro melting point apparatus, and were uncorrected. Optical rotations were measured on a JASCO P-2200. IR spectra were measured with a SHIMADZU FTIR-8700 spectrometer for samples in $CHCl_3$. ^1H and ^{13}C NMR spectra were measured with a JEOL JNM-ECS400 or JNM-ECA600 or BRUKER AVANCE-600 spectrometers for samples in $CDCl_3$. Tetramethylsilane (0.00 ppm) for ^1H NMR and $CDCl_3$ (77.00 ppm) for ^{13}C NMR were used as an internal standard, respectively. High resolution mass spectra were measured with a JEOL JMS-T100TD or JMS-SX102A or JMS-HX110. Commercially available reagents were used throughout without purification unless otherwise stated. $CHCl_3$, $(CH_2Cl)_2$, Et_3N and MeOH were distilled from calcium hydride under a nitrogen atmosphere. EtOH was distilled from CaO under a nitrogen atmosphere. DMF, DMSO and NMP were distilled from calcium sulfate under a nitrogen atmosphere. Silica gel (silica gel 60N, 40-50 μm, Kanto Chemical) was used for chromatography. All reactions were carried out under a nitrogen atmosphere unless otherwise stated. Organic extracts were dried over anhydrous Na_2SO_4. Bromocyclophanyl triflate (S_p)-**8**,[1] diazo compounds **16**,[2] **18**[3] and **20**,[4] and $NaBAr_F$[5] were prepared according to the literature procedure.

2-(3-Bromophenyl)oxazoline (12a).[6]

To *m*-bromobenzoic acid (**11**) (3.36 g, 16.7 mmol) was added $SOCl_2$ (3.9 mL, 50 mmol) at room temperature. After stirring for 23 h at 50 ºC, volatiles were evaporated. The residue was dissolved in CH_2Cl_2 (10 mL) and added in a dropwise manner to a solution of monoethanolamine (5.0 mL, 84 mmol) in CH_2Cl_2 (10 mL) at 0 ºC. The mixture was stirred for 15 h at room temperature. The white precipitate was filtered and washed with water to afford 3-bromo-*N*-(2-hydroxyethyl)benzamide (3.86 g, 95%) as a colorless solid; Mp 105 ºC; IR 3447, 1655 cm^{-1}; ^1H NMR (600 MHz, $CDCl_3$): δ 7.92 (t, 1H, J = 1.7 Hz), 7.70 (d, 1H, J = 7.9 Hz), 7.63 (dt, 1H, J = 8.1, 1.0 Hz), 7.31 (t, 1H, J = 7.9 Hz), 6.68 (brs, 1H), 3.84 (q, 2H, J = 5.2 Hz), 3.63 (t, 2H, J = 5.5, 4.8 Hz), 2.57 (t, 1H, J = 5.0 Hz) ; ^{13}C NMR (150 MHz, $CDCl_3$): δ 170.0, 136.1, 134.6, 130.2, 130.2, 125.5, 122.8, 62.1, 42.8; MS (DART) *m/z* 246 (94.6, M^++1), 244 (100.0, M^++1); HRMS calcd for $C_9H_{11}BrNO_2$: 243.9973, found 243.9983.

To the above amide (3.86 g, 15.8 mmol) was added $SOCl_2$ (3.6 mL) at room temperature. The reaction mixture was stirred for 1 h at the same temperature and Et_2O (4 mL) was added. The mixture was neutralized with 50% NaOH aqueous solution and extracted with

AcOEt. The extract was washed with water and brine, dried and concentrated to dryness. The residue was dissolved in THF (10 mL) and NaH (60% dispersion of mineral oil) was added until the chloride product disappeared (monitored by TLC). The mixture was quenched with water and extracted with Et_2O. The extract was washed with water and brine, dried and concentrated to dryness. The residue was chromatographed with hexane-AcOEt (2:1) to afford **12a** (3.01 g, 84%) as a colorless solid; Mp 38 ºC; IR 1649 cm^{-1}; ^1H NMR (600 MHz, $CDCl_3$): δ 8.10 (t, 1H, J = 1.7 Hz), 7.87 (dt, 1H, J = 7.8, 1.3 Hz), 7.60 (dq, 1H, J = 7.9, 1.0 Hz), 7.28 (t, 1H, J = 7.9 Hz), 4.44 (t, 2H, J = 9.6 Hz), 4.07 (t, 2H, J = 9.5 Hz); ^{13}C NMR (150 MHz, $CDCl_3$): δ 163.3, 134.2, 131.2, 129.9, 129.7, 126.7, 122.3, 67.8, 54.9; MS (DART) *m/z* 228 (100.0, M^++1), 226 (98.1, M^++1); HRMS calcd for C_9H_9BrNO: 225.9868, found 225.9861.

2-(4-Bromobiphenyl-2-yl)oxazoline (12b).

To a solution of **12a** (862 mg, 3.82 mmol) in NMP (7.6 mL) were added K_2CO_3 (1.06 g, 7.64 mmol), PPh_3 (100 mg, 0.382 mmol), PhI (0.55 mL, 5.0 mmol) and $[RuCl_2(\eta\text{-benzene})]_2$ (47.8 mg, 0.0955 mmol) at room temperature. After stirring for 24 h at 120 ºC, the mixture was cooled to room temperature, and diluted with Et_2O. The mixture was washed with water and brine, dried and concentrated to dryness. The residue was chromatographed with CH_2Cl_2-AcOEt (40:1) to afford **12b** (333 mg, 29%) as a colorless oil; IR 1653 cm^{-1}; ^1H NMR (600 MHz, $CDCl_3$): δ 7.93 (d, 1H, J = 2.1 Hz), 7.61 (dd, 1H, J = 8.2, 2.1 Hz), 7.40-7.32 (m, 5H), 7.25 (d, 1H, J = 8.2 Hz), 4.12 (t, 2H, J = 9.6 Hz), 3.91 (t, 2H, J = 9.6 Hz); ^{13}C NMR (150 MHz, $CDCl_3$): δ 164.7, 140.8, 140.1, 133.5, 132.9, 131.9, 129.2, 128.1, 128.1, 127.5, 121.0, 68.0, 55.0; MS (DART) *m/z* 304 (98.7, M^++1), 302 (100.0, M^++1); HRMS calcd for $C_{15}H_{13}BrNO$: 302.0181, found 302.0176.

2-(4-Bromo-3',5'-dimethylbiphenyl-2-yl)oxazoline (12c).

According to the procedure for preparation of **12b** from **12a**, **12c** (526 mg, 36%) was obtained from **12a** (997 mg, 4.41 mmol); A colorless oil; IR 1653, 1603 cm^{-1}; ^1H NMR (600 MHz, $CDCl_3$): δ 7.91 (d, 1H, J = 2.1 Hz), 7.60 (dd, 1H, J = 8.2, 2.4 Hz), 7.27 (s, 1H), 7.00-6.99 (m, 3H), 4.16 (t, 2H, J = 9.5 Hz), 3.94 (t, 2H, J = 9.5 Hz), 2.35 (s, 6H); ^{13}C NMR (150 MHz, $CDCl_3$): δ 164.9, 140.9, 139.8, 137.6, 133.4, 132.9, 131.9, 129.2, 129.2, 126.0, 120.8, 68.0, 55.0, 21.3; MS (DART) *m/z* 332 (96.1, M^++1), 330 (100.0, M^++1); HRMS calcd for $C_{17}H_{17}BrNO$: 330.0494, found 330.0479.

2-(4-Bromo-1,1':4',1''-terphenyl-2-yl)oxazoline (12d).

According to the procedure for preparation of **12b** from **12a**, **12d** (38.4 mg, 23%) was obtained from **12a** (100 mg, 0.442 mmol); A colorless solid; Mp 167-168 ºC; IR 1653 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ 7.95 (d, 1H, J = 1.8 Hz), 7.65-7.62 (m, 5H), 7.48-7.41 (m, 4H), 7.36 (t, 1H, J = 7.3 Hz), 7.30 (d, 1H, J = 8.2 Hz), 4.17 (t, 2H, J = 9.6 Hz), 3.94 (t, 2H, J = 9.4 Hz); ^{13}C NMR (150 MHz, $CDCl_3$): δ 164.7, 140.5, 140.3, 140.3, 139.1, 133.5, 133.0, 131.9, 129.2, 128.8, 128.6, 127.4, 127.0, 126.8, 121.1, 68.0, 55.1; MS (DART) m/z 380 (99.0, M^++1), 378 (100.0, M^++1); HRMS calcd for $C_{21}H_{17}BrNO$: 378.0494, found 378.0496.

2-Isopropylbenzoic acid (14).[7]

To a solution of **13** (199 mg, 1.00 mmol) in THF (3.3 mL) was added *n*-BuLi (1.54 M in hexane, 0.97 mL, 1.5 mmol) at -78 ºC. After stirring for 0.5 h at the same temperature, anhydrous CO_2 was bubbled through the mixture for 1 h. Then the mixture was stirred for an additional 20 min at room temperature, quenched with aqueous solution of saturated $NaHCO_3$, and washed with Et_2O. Aqueous layer was acidified with aqueous solution of 10% HCl and extracted with Et_2O. The extract was dried and concentrated to dryness to afford **14** (168.8 mg, 100%) as a colorless solid; IR 2970, 1693 cm^{-1}; ^1H NMR (600 MHz, $CDCl_3$): δ 7.92 (d, 1H, J = 7.6 Hz), 7.52 (m, 1H), 7.46 (d, 1H, J = 7.9 Hz), 7.28-7.26 (m, 1H), 3.93 (sep, 1H, J = 6.9 Hz), 1.28 (d, 6H, J = 6.9 Hz); ^{13}C NMR (150 MHz, $CDCl_3$): δ 174.1, 151.0, 132.8, 130.9, 128.3, 126.5, 125.5, 29.3, 24.0; MS (DART) m/z 165 (M^++1, 100.0); HRMS calcd for $C_{10}H_{13}O_2$: 165.0916, found 165.0930.

5-Bromo-2-isopropylbenzoic acid (15).

To bromine (1.54 g, 9.62 mmol) in CH_2Cl_2 (7 mL) was added Fe (26.9 mg, 0.481 mmol) at room temperature. After stirring for 40 min, a solution of **14** (1.17 g, 4.81 mmol) in CH_2Cl_2 (7 mL) was added to the mixture. After stirring at refluxing temperature for 15 h, the mixture was cooled to room temperature and quenched with aqueous solution of saturated $Na_2S_2O_3$. The mixture was filtered and filtrate was extracted with CH_2Cl_2. The extract was washed with aqueous solution of saturated $Na_2S_2O_3$, water and aqueous solution of 10% HCl, dried and concentrated to the dryness. The residue was chromatographed with hexane-AcOEt (5:1) to afford a mixture of **15** and starting material **14** (1.39 g) as a yellow

solid. **15**: Mp 98-100 ºC; IR 2970, 2635, 1697 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ 8.06 (d, 1H, J = 2.3 Hz), 7.63 (dd, 1H, J = 8.2, 2.3 Hz), 7.34 (d, 1H, J = 8.2 Hz), 3.88 (sep, 1H, J = 6.9 Hz), 1.26 (d, 6H, J = 6.9 Hz); ^{13}C NMR (150 MHz, $CDCl_3$): δ 171.9, 150.0, 135.7, 133.5, 129.8, 128.4, 119.0, 29.1, 23.8; MS (DART) m/z 245 (66.3, M^++1), 243 (100.0, M^++1); HRMS calcd for $C_{10}H_{12}BrO_2$: 243.0021, found 243.0017.

2-(5-Bromo-2-isopropylphenyl)oxazoline (12e).

To the above mixture of **14** and **15** was added $SOCl_2$ (4 mL) at room temperature. After being stirred for 5 h at 50 ºC, the volatiles were evaporated. The residue was dissolved in CH_2Cl_2 (4.1 mL) and added in a dropwise manner to a solution of monoethanolamine (1.7 mL) in CH_2Cl_2 (4.1 mL) at 0 ºC. The reaction mixture was stirred for 10 h at room temperature and extracted with CH_2Cl_2. The extract was washed with water and brine, dried and concentrated to dryness to afford the crude amide (1.79 g) as a yellow solid: IR 3437, 1655 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ 7.49 (dd, 1H, J = 8.6, 2.1 Hz), 7.40 (d, 1H, J = 2.1 Hz), 7.23 (d, 1H, J = 8.2 Hz), 6.43 (brs, 1H), 3.78 (q, 2H, J = 5.2 Hz), 3.54 (q, 2H, J = 5.4 Hz), 3.24 (sep, 1H, J = 6.9 Hz), 2.82 (t, 1H, J = 5.0 Hz), 1.22 (d, 6H, J = 6.9 Hz). ^{13}C NMR (150 MHz, $CDCl_3$): δ 169.9, 145.6, 137.5, 133.0, 129.3, 128.0, 119.0, 61.9, 42.5, 29.7, 23.9; MS (DART) m/z 288 (93.2, M^++1), 286 (100.0, M^++1); HRMS calcd for $C_{12}H_{17}BrNO_2$: 286.0443, found 286.0438.

To the crude amide was added $SOCl_2$ (1.4 mL) at room temperature. The reaction mixture was stirred for 0.5 h, and Et_2O (3 mL) was added. The mixture was neutralized with aqueous solution of 20% NaOH and extracted with AcOEt. The extract was washed with water and brine, dried and concentrated to dryness. The residue was dissolved in THF (3 mL) and NaH (60% dispersion of mineral oil) was added to the mixture until chloro derivatives disappeared (monitored by TLC). The mixture was quenched with water and extracted with Et_2O. The extract was washed with water and brine, dried and concentrated to dryness. The residue was chromatographed with hexane-AcOEt (9:1) to afford **12e** (929 mg, 72%) as a colorless oil; IR 1650 cm^{-1}; ^1H NMR (600 MHz, $CDCl_3$): δ 7.82 (d, 1H, J = 2.4 Hz), 7.51 (dd, 1H, J = 8.6, 2.4 Hz), 7.25 (d, 1H, J = 8.6 Hz), 4.40 (t, 2H, J = 9.6 Hz), 4.09 (t, 2H, J = 9.6 Hz), 3.76 (sep, 1H, J = 6.9 Hz), 1.22 (d, 6H, J = 6.9 Hz). ^{13}C NMR (150 MHz, $CDCl_3$): δ 164.0, 148.1, 133.6, 132.5, 128.7, 127.8, 118.9, 67.2, 55.5, 29.3, 23.8; MS (DART) m/z 270 (67.4, M^++1), 268 (69.0, M^++1); HRMS calcd for $C_{12}H_{15}BrNO$: 268.0337, found 268.0354.

Typical procedure for preparation of boronic acids 7.

2-[4-(Dihydroxyboryl)biphenyl-2-yl]oxazoline (7b).

To a solution of **12b** (84.7 mg, 0.280 mmol) in THF (1 mL) was added *n*-BuLi (1.43 M in hexane, 0.23 mL, 0.34 mmol) under an argon atmosphere at -78 ºC. After stirring for 20 min at the same temperature, $B(OMe)_3$ (0.13 mL, 1.1 mmol) was added to the mixture at -78 ºC, which was stirred for 30 min at the same temperature, and warmed to -15 ºC over 50 min. Aqueous solution of 5% HCl (1 mL) was added and the mixture was further stirred for 20 min at -15 ºC, basified with aqueous solution of 10% NaOH (1 mL), warmed to room temperature, and washed with Et_2O. Aqueous layer was neutralized with aqueous solution of 10% HCl, and extracted with Et_2O. The extract was washed with brine, dried and concentrated to dryness to afford the crude **7b** (38.4 mg, 51%) as a yellow solid, which was used without purification. Spectroscopic data of the boronic acid were not taken due to its instability.

Typical procedure for Suzuki-Miyaura coupling of boronic acid 7 and bromo-cyclophanyl triflate (S_p)-8.

(S_p)-(-)-4,12-Bis[2-(2-oxazolinyl)biphenyl-4-yl][2.2]paracyclophane ((S_p)-6b).

To a solution of (S_p)-**8** (44.0 mg, 0.101 mmol) in DMSO (0.67 mL) and H_2O (67 μL) were added Na_2CO_3 (42.8 mg, 0.404 mmol), **7b** (108 mg, 0.404 mmol) and $Pd(PPh_3)_4$ (12.0 mg, 0.0104 mmol) at room temperature under an argon atmosphere. After stirring for 6 h at 100 ºC, the mixture was cooled to room temperature, diluted with water, and extracted with AcOEt. The extract was washed with water and brine, dried and concentrated to dryness. The residue was chromatographed with hexane/AcOEt (1:1) to afford (S_p)-**6b** (51.2 mg, 78%) as a colorless solid; Mp 130-132 ºC; $[\alpha]_D^{30}$ -204.9 (*c* 1.43, $CHCl_3$); IR 1651 cm^{-1}; ^1H NMR (600 MHz, $CDCl_3$): δ 7.80 (s, 2H), 7.60 (d, 2H, *J* = 8.2 Hz), 7.46-7.32 (m, 12H), 6.77-6.74 (m, 4H), 6.66 (d, 2H, *J* = 7.9 Hz), 4.11-4.05 (m, 4H), 3.87-3.84 (m, 4H), 3.63-3.59 (m, 2H), 3.16-3.12 (m, 2H), 3.03-2.97 (m, 2H), 2.81-2.76 (m. 2H); ^{13}C NMR (150 MHz, $CDCl_3$): δ 165.8, 140.9, 140.0, 139.8, 139.7, 139.2, 137.1, 135.7, 132.5, 131.0, 131.0, 130.5, 129.9, 128.3, 128.0, 127.6, 127.1, 67.7, 55.1, 34.5, 34.5; MS (DART) *m*/*z* 651 (M^++1, 100.0); HRMS calcd for $C_{46}H_{39}N_2O_2$: 651.3012, found 651.3001.

(S_p)-(-)-4,12-Bis[3-(2-oxazolinyl)phenyl][2.2]paracyclophane ((S_p)-6a).

According to the procedure for preparation of **6b** from (S_p)-**8** and **7b**, **(S_p)-6a** (28.0 mg, 66%) was obtained from (S_p)-**8** (38.3 mg, 0.0880 mmol) and **7a** (108 mg, 0.352 mmol); A colorless solid; Mp 88-90 ºC; $[\alpha]_D^{30}$ -164.4 (*c* 0.94, $CHCl_3$); IR 1649 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ 7.95-7.94 (m, 4H), 7.51 (d, 2H, *J* = 7.8 Hz), 7.45 (t, 2H, *J* = 7.8 Hz), 6.73 (d, 2H, *J* = 7.8 Hz), 6.69-6.64 (m, 2H), 4.38 (t, 4H, *J* = 9.6 Hz), 4.05 (t, 4H, *J* = 9.6 Hz), 3.58-3.52 (m, 2H), 3.12 (t, 2H, *J* = 11.7 Hz), 2.97 (ddd, 2H, *J* = 12.8, 9.6, 6.4 Hz), 2.73 (ddd, 2H, *J* = 12.8, 9.6, 6.4 Hz); ^{13}C NMR (150 MHz, $CDCl_3$): δ 164.7, 141.1, 139.7, 139.6, 137.0, 135.7, 132.4, 131.9, 130.0, 128.9, 128.5, 127.9, 126.4, 67.6, 54.9, 34.4, 34.4; MS (DART) *m*/*z* 499 (M^++1, 100.0); HRMS calcd for $C_{34}H_{31}N_2O_2$: 499.2386, found 499.2405.

(S_p)-(-)-4,12-Bis[3-(2-oxazolinyl)-4-(3,5-dimethylphenyl)phenyl][2.2]paracyclophane ((S_p)-6c).

According to the procedure for preparation of **6b** from (S_p)-**8** and **7b**, **(S_p)-6c** (80.7 mg, 88%) was obtained from (S_p)-**8** (56.5 mg, 0.130 mmol) and **7c** (126 mg, 0.428 mmol); A colorless solid; Mp 126-128 ºC; $[\alpha]_D^{22}$ -212.9 (*c* 0.81, $CHCl_3$); IR 1651 cm^{-1}; ^1H NMR (600 MHz, $CDCl_3$): δ 7.76 (s, 2H), 7.57 (d, 2H, *J* = 6.9 Hz), 7.46 (d, 2H, *J* = 7.9 Hz), 7.09 (s, 4H), 6.98 (s, 2H), 6.76 (s, 2H), 6.74 (d, 2H, *J* = 7.9 Hz), 6.66 (d, 2H, *J* = 7.6 Hz), 4.13-4.08 (m, 4H), 3.88 (t, 4H, *J* = 9.3 Hz), 3.60 (t, 2H, *J* = 11.3 Hz), 3.13 (t, 2H, *J* = 11.3 Hz), 3.01-2.96 (m, 2H), 2.80-2.75 (m, 2H), 2.36 (s, 12H); ^{13}C NMR (150 MHz, $CDCl_3$): δ 166.0, 140.6, 140.0, 139.7, 139.6, 139.2, 137.4, 137.0, 135.6, 132.4, 131.0, 130.9, 130.5, 129.9, 128.9, 127.5, 126.2, 67.8, 55.2, 34.5, 34.4, 21.4; MS (DART) *m*/*z* 707 (53.3, M^++1); HRMS calcd for $C_{50}H_{47}N_2O_2$: 707.3638, found 707.3654.

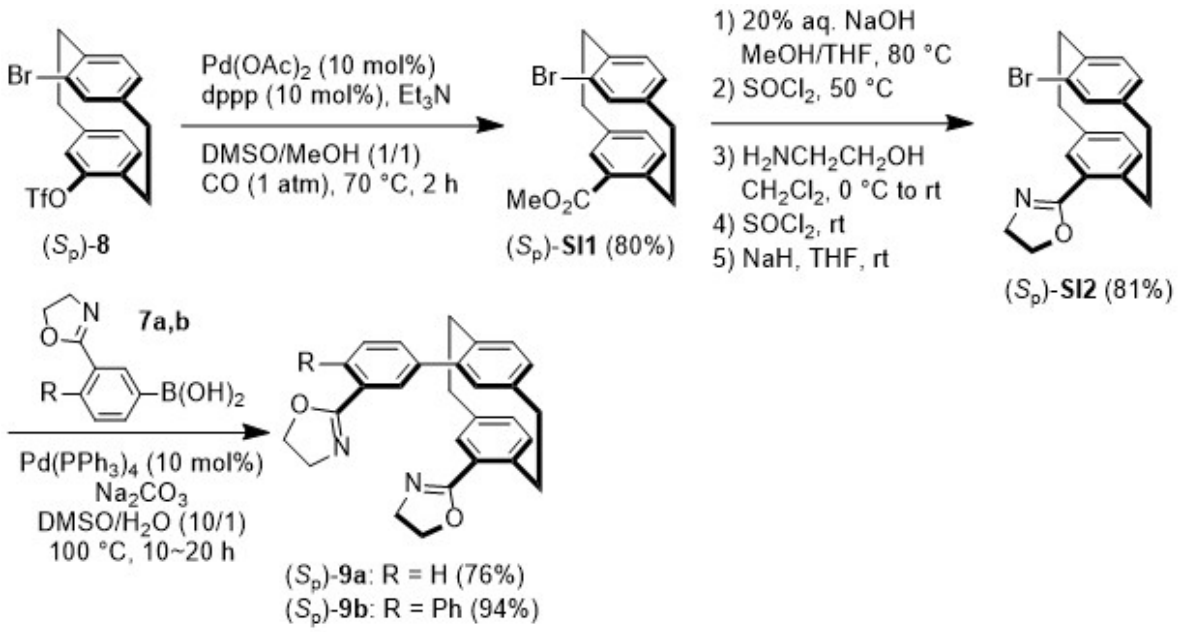
(S_p)-(-)-4,12-Bis[2-(2-oxazolinyl)-1,1':4',1''-terphenyl-4-yl][2.2]paracyclophane ((S_p)-6d).

According to the procedure for preparation of **6b** from (S_p)-**8** and **7b**, **(S_p)-6d** (37.1 mg, 57%) was obtained from (S_p)-**8** (34.8 mg, 0.0805 mmol) and **7d** (110 mg, 0.322 mmol); A colorless solid; Mp 159-161 ºC; $[\alpha]_D^{21}$ -297.4 (*c* 1.70, $CHCl_3$); IR 1653 cm^{-1}; ^1H NMR (600 MHz, $CDCl_3$): δ 7.82 (d, 2H, *J* = 2.1 Hz), 7.67-7.64 (m, 8H), 7.63 (dd, 2H, *J* = 7.9, 1.7 Hz), 7.54-7.51 (m, 6H), 7.47-7.44 (m, 4H), 7.37-7.34 (m, 2H), 6.79 (d, 2H, *J* = 1.7 Hz), 6.77 (d, 2H, *J* = 7.9 Hz), 6.68 (dd, 2H, *J* = 7.9, 1.7 Hz), 4.16-4.10 (m, 4H), 3.92-3.88 (m, 4H), 3.64-3.61 (m, 2H), 3.16 (t, 2H, *J*=11.7 Hz), 3.01 (ddd, 2H, *J* = 13.3, 10.2, 6.6 Hz), 2.81 (ddd, 2H, *J* = 12.9, 9.8, 6.7 Hz) ; ^{13}C NMR (600 MHz, $CDCl_3$): δ 165.8, 140.7, 139.9,

139.9, 139.8, 139.5, 139.2, 137.1, 135.7, 132.5, 131.1, 131.0, 130.5, 129.9, 128.8, 127.5, 127.3, 127.0, 126.8, 67.8, 55.2, 34.5, 34.5. HRMS (FAB+) calcd for $C_{58}H_{47}N_2O_2$: 803.3637, found 803.3626.

(S_p)-(-)-4,12-Bis[4-isopropyl-3-(2-oxazolinyl)phenyl][2.2]paracyclophane ((S_p)-6e). According to the procedure for preparation of **6b** from (S_p)-**8** and **7b**, **(S_p)-6e** (86.8 mg, 89%) was obtained from (S_p)-**8** (72.6 mg, 0.167 mmol) and **7e** (136 mg, 0.584 mmol); A colorless solid; Mp 101-103 ºC; $[\alpha]_D^{22}$ -201.5 (*c* 1.03, $CHCl_3$); IR 1647 cm^{-1}; ^1H NMR (600 MHz, $CDCl_3$): δ 7.73 (d, 2H, *J* = 1.7 Hz), 7.47 (dd, 2H, *J* = 8.2, 2.1 Hz), 7.42 (d, 2H, *J* = 8.2 Hz), 6.71 (d, 2H, *J* = 7.9 Hz), 6.67 (s, 2H), 6.61 (d, 2H, *J* = 6.5 Hz), 4.33 (t, 4H, *J* = 9.6 Hz), 4.08 (t, 4H, *J* = 9.6 Hz), 3.90 (sep, 2H, *J* = 6.9 Hz), 3.54-3.50 (m, 2H), 3.10-3.06 (m, 2H), 2.90 (ddd, 2H, *J* = 13.6, 10.1, 7.0 Hz), 2.66 (ddd, 2H, *J* = 13.1, 9.6, 7.2 Hz), 1.30 (d, 6H, *J* = 6.8 Hz), 1.29 (d, 6H, *J* = 6.8 Hz); ^{13}C NMR (150 MHz, $CDCl_3$): δ 165.1, 147.3, 139.6, 139.6, 138.1, 137.0, 135.5, 132.0, 131.2, 130.6, 129.9, 126.7, 126.0, 66.9, 55.6, 34.6, 34.3, 29.2, 24.0, 23.9; MS (DART) *m*/*z* 583 (M^++1, 100.0); HRMS calcd for $C_{40}H_{43}N_2O_2$: 583.3325, found 583.3306.

Preparation of (S_p)-9a,b.



(S_p)-(+)-4-Bromo-12-carbomethoxy[2.2]paracyclophane ((S_p)-SI1).[8]

To a solution of (S_p)-**8** (154 mg, 0.353 mmol) in MeOH (1.5 mL) and DMSO (1.5 mL) were added $Pd(OAc)_2$ (7.9 mg, 0.035 mmol), dppp (14.6 mg, 0.035 mmol) and Et_3N (0.2 mL) at room temperature. After stirring for 2 h at 70 ºC under a CO atmosphere, the reaction mixture was cooled to room temperature, diluted with water, and extracted with Et_2O. The extract was washed with water and brine, dried and concentrated to dryness. The residue was chromatographed with hexane-AcOEt (30:1) to afford (S_p)-**SI1** (97.1 mg, 80%) as a colorless solid; Mp 106-108 ºC; $[\alpha]_D^{19}$ +121.2 (*c* 1.15, $CHCl_3$); IR 1711 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ 7.76 (d, 1H, *J* = 1.8 Hz), 6.67-6.54 (m, 4H), 6.48 (d, 1H, *J* = 7.8 Hz), 4.06 (ddd, 1H, *J* = 12.6, 9.8, 1.1 Hz), 3.92 (s, 3H), 3.47 (ddd, 1H, *J* = 13.3, 10.1, 1.4 Hz), 3.26-3.18 (m, 1H), 3.15-2.97 (m, 3H), 2.87-2.76 (m, 2H); ^{13}C NMR (150 MHz, methanol-d4): δ 169.0, 143.4, 143.4, 140.9, 140.2, 138.2, 137.3, 136.5, 136.3, 132.7, 131.9, 131.5, 127.5, 52.2, 36.7, 36.4, 34.8, 33.5; MS (DART) *m*/*z* 347 (98.6, M^++1), 345 (100.0, M^++1); HRMS calcd for $C_{18}H_{18}BrO_2$: 345.0490, found 345.0483.

(S_p)-(+)-4-Bromo-12-(2-oxazolinyl)[2.2]paracyclophane ((S_p)-SI2).

To a solution of (S_p)-**SI1** (93.1 mg, 0.270 mmol) in MeOH (1 mL) and THF (1 mL) was added aqueous solution of 20% NaOH (3 mL) at room temperature. After stirring for 18 h at 80 ºC, the reaction mixture was cooled to room temperature, acidified with aqueous solution of 10 % HCl, and extracted with AcOEt. The extract was washed with water and brine, dried and concentrated to dryness to afford the crude carboxylic acid (90.2 mg, quant.) as a yellow solid; Mp 204-206 ºC; $[\alpha]_D^{24}$ +135.0 (*c* 1.07, $CHCl_3$); IR 3520, 2935, 1684 cm^{-1}; ^1H NMR (600 MHz, $CDCl_3$): δ 7.95 (s, 1H), 6.72-6.61 (m, 4H), 6.50 (d, 1H, *J* = 7.9 Hz), 4.19 (t, 1H, *J* = 11.3 Hz), 3.50 (t, 1H,. *J* = 11.9 Hz), 3.29-3.24 (m, 1H), 3.18-3.06 (m, 3H), 2.90-2.79 (m, 2H); ^{13}C NMR (150 MHz, $CDCl_3$): δ 172.4, 143.1, 142.1, 139.7, 138.9, 137.7, 136.2, 135.8, 135.0, 131.9, 131.1, 129.3, 126.8, 36.3, 35.8, 34.1, 32.5; MS (DART) *m*/*z* 333 (44.2, M^++1), 331 (42.9, M^++1); HRMS calcd for $C_{17}H_{16}BrO_2$: 331.0334, found 331.0324.

To the above carboxylic acid (89.8 mg, 0.271 mmol) was added $SOCl_2$ (0.5 mL) at room temperature. After stirring for 16 h at 50 ºC, the volatiles were evaporated. The residue was dissolved in CH_2Cl_2 (0.5 mL) and added in dropwise manner to a solution of ethanolamine (0.1 mL) in CH_2Cl_2 (0.5 mL) at 0 ºC. The mixture was stirred for 2 h at room temperature, diluted with water and extracted with CH_2Cl_2. The extract was washed with water and brine,

dried and concentrated to dryness to afford the crude amide (96.7 mg, 95%) as a yellow solid; $[\alpha]_D^{20}$ +67.1 (*c* 1.04, $CHCl_3$); IR 3420, 1647 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ 7.24 (d, 1H, *J* = 1.8 Hz), 6.81 (d, 1H, *J* = 1.9 Hz), 6.63-6.59 (m, 3H), 6.53 (d, 1H, *J*= 7.8 Hz), 6.45 (brs, 1H), 3.90-3.87 (m, 2H), 3.82-3.77 (m, 1H), 3.72-3.64 (m, 1H), 3.59-3.52 (m, 1H), 3.48-3.42 (m, 1H), 3.18-3.09 (m, 2H), 3.06-3.02 (m, 2H), 2.90-2.78 (m, 2H). ^{13}C NMR (150 MHz, $CDCl_3$): δ 170.0, 142.2, 139.6, 139.6, 138.6, 135.9, 135.4, 135.1, 134.8, 134.7, 131.5, 126.8, 126.5, 62.6, 42.7, 35.6, 34.6, 34.4, 32.5. MS (DART) *m*/*z* 376 (100.0, M^++1), 374 (99.9, M^++1); HRMS calcd for $C_{19}H_{21}BrNO_2$: 374.0756, found 374.0769.

To the above amide (96.7 mg, 0.258 mmol) was added $SOCl_2$ (0.5 mL) at room temperature. The reaction mixture was stirred for 10 min at the same temperature and Et_2O was added. The mixture was basified with aqueous solution of 20% NaOH at 0 ºC and extracted with Et_2O. The extract was washed with water and brine, dried and concentrated to dryness. The residue was dissolved in THF (2 mL) and NaH (60% dispersion of mineral oil) was added to the mixture until chloro derivative disappeared (monitored by TLC). The precipitate was filtered and filtrate was concentrated to dryness. The residue was chromatographed with hexane-AcOEt (9:1) to afford (S_p)-**SI2** (81.0 mg, 88%) as a colorless solid; Mp 164-166 ºC; $[\alpha]_D^{19}$ +79.6 (*c* 1.50, $CHCl_3$); IR 1636 cm^{-1}; ^1H NMR (600 MHz, $CDCl_3$): δ 7.68 (d, 1H, *J* = 1.7 Hz), 6.61-6.55 (m, 4H), 6.48 (d, 1H, *J* = 7.9 Hz), 4.45-4.34 (m, 2H), 4.22-4.06 (m, 3H), 3.46 (ddd, 1H, *J* = 13.3, 10.1, 1.5 Hz), 3.19 (ddd, 1H, *J* = 13.8, 10.1, 6.8 Hz), 3.07 (dd, 2H, *J* = 12.9, 10.8 Hz), 2.96 (ddd, 1H, *J* = 14.4, 10.1, 7.4 Hz), 2.83-2.76 (m, 2H); ^{13}C NMR (150 MHz, $CDCl_3$): δ 164.4, 142.0, 140.5, 139.2, 138.8, 135.6, 135.1, 135.0, 134.9, 131.2, 130.3, 128.0, 126.6, 66.6, 55.5, 36.0, 35.8, 33.8, 32.6; MS (DART) *m*/*z* 358 (98.4, M^++1), 356 (100.0, M^++1); HRMS calcd for $C_{19}H_{19}BrNO$: 356.0650, found 356.0643.

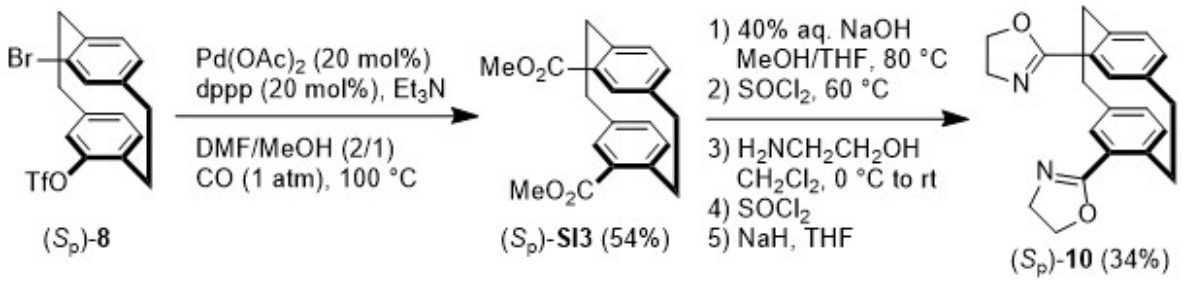
(S_p)-(-)-4-(2-Oxazolinyl)-12-[2-(2-oxazolinyl)-1,1'-biphenyl-4-yl][2.2]paracyclophane ((S_p)-9b).

To a solution of (S_p)-**SI2** (30.9 mg, 0.0867 mmol) in DMSO (0.6 mL) and H_2O (58 μL) were added Na_2CO_3 (18.3 mg, 0.173 mmol), **7b** (46.3 mg, 0.173 mmol) and $Pd(PPh_3)_4$ (10.0 mg, 0.00867 mmol) at room temperature under an argon atmosphere. After stirring for 10 h at 100 ºC, the reaction mixture was cooled to room temperature, diluted with water, and extracted with AcOEt. The extract was washed with water and brine, dried and concentrated to dryness. The residue was chromatographed with benzene-acetonitrile (7:1)

to afford (S_p)-**9b** (40.6 mg, 94%) as a colorless solid; Mp 112-114 ºC; $[\alpha]_D^{23}$ -90.7 (*c* 1.10, $CHCl_3$); IR 1639 cm^{-1}; ^1H NMR (600 MHz, $CDCl_3$): δ 8.07 (d, 1H, *J* = 1.7 Hz), 7.72 (dd, 1H, *J* = 7.9, 1.7 Hz), 7.47-7.40 (m, 5H), 7.37-7.34 (m, 1H), 6.70-6.64 (m, 5H), 6.61 (dd, 1H, *J* = 7.6, 1.7 Hz), 4.58 (dt, 1H, *J* = 9.6, 8.2 Hz), 4.43 (dt, 1H, *J* = 10.0, 8.6 Hz), 4.30-4.09 (m, 5H), 4.02-3.92 (m, 2H), 3.65-3.61 (m, 1H), 3.21 (dd, 1H, *J* = 13.1, 9.6 Hz), 3.01-2.93 (m, 2H), 2.89-2.82 (m, 2H), 2.50 (ddd, 1H, *J* = 13.5, 9.7, 7.5 Hz); ^{13}C NMR (150 MHz, $CDCl_3$): δ 166.3, 164.3, 141.1, 140.9, 140.3, 140.2, 140.1, 139.9, 139.5, 136.8, 135.9, 135.6, 134.9, 132.0, 131.9, 131.5, 130.9, 130.9, 130.5, 128.2, 128.0, 127.7, 127.4, 127.1, 67.7, 66.6, 55.3, 55.0, 36.4, 34.9, 34.1, 33.8; MS (DART) *m*/*z* 499 (100.0, M^++1); HRMS calcd for $C_{34}H_{31}N_2O_2$: 499.2386, found 499.2384.

(S_p)-(-)-4-(2-Oxazolinyl)-12-[3-(2-oxazolinyl)phenyl][2.2]paracyclophane ((S_p)-9a). According to the procedure for preparation of **9b** from (S_p)-**SI2** and **7b**, **(S_p)-9a** (15.0 mg, 76%) was obtained from (S_p)-**SI2** (17.3 mg, 0.0486 mmol) and **7a** (18.5 mg, 0.0971 mmol); A colorless solid; Mp 57-59 ºC; $[\alpha]_D^{18}$ -130.3 (*c* 0.34, $CHCl_3$); IR 1647 cm^{-1}; ^1H NMR(600 MHz, $CDCl_3$): δ 8.20 (t, 1H, *J* = 1.5 Hz), 7.93 (dt, 1H, *J* = 7.9, 1.4 Hz), 7.73 (dt, 1H, *J* =7.7, 1.4 Hz), 7.49 (t, 1H, *J* = 7.7 Hz), 7.20 (d, 1H, *J* = 1.4 Hz), 6.69-6.60 (m, 5H), 4.64 (dt, 1H, *J* = 10.0, 8.2 Hz), 4.50-4.43 (m, 3H), 4.29-4.18 (m, 3H), 4.13-4.09 (m, 2H), 3.58 (ddd, 1H, *J* = 13.5, 9.7, 1.3 Hz), 3.21 (dd, 1H, *J* = 12.9, 9.8 Hz), 3.00 (dt, 1H, *J* = 12.5, 8.9 Hz), 2.94-2.79 (m, 3H), 2.40 (ddd, 1H, *J* = 13.1, 9.7, 7.6 Hz); ^{13}C NMR (150 MHz, $CDCl_3$): δ 164.9, 164.3, 141.1, 140.9, 140.7, 140.2, 139.5, 136.8, 136.0, 135.7, 134.8, 132.9, 131.9, 131.5, 130.9, 129.0, 128.5, 128.1, 127.4, 126.7, 67.6, 66.8, 55.4, 55.0, 36.4, 34.9, 34.1, 33.7; MS (DART) *m*/*z* 423 (100.0, M^++1); HRMS calcd for $C_{28}H_{27}N_2O_2$: 423.2073, found 423.2077.

Preparation of (S_p)-10.



(S_p)-(+)-4,12-Bis(carbomethoxy)[2.2]paracyclophane ((S_p)-SI3).[9]

To a solution of (S_p)-**8** (37.4 mg, 0.0859 mmol) in MeOH (0.3 mL) and DMF (0.6 mL) were added dppf (9.5 mg, 0.017 mmol), Et_3N (0.05 mL) and $Pd(OAc)_2$ (3.9 mg, 0.017 mmol) at room temperature. After stirring for 47 h at 100 ºC under a CO atmosphere, the reaction mixture was cooled to room temperature, diluted with water, and extracted with AcOEt. The extract was washed with water and brine, dried and concentrated to dryness. The residue was chromatographed with hexane-AcOEt (20:1) to afford (S_p)-**SI3** (15.0 mg, 54%) as a colorless solid; Mp 176-178 ºC; $[\alpha]_D^{18}$ +119.0 (*c* 1.83, $CHCl_3$); IR 1713 cm^{-1}; ^1H NMR (600 MHz, $CDCl_3$) δ 7.14 (d, 2H, *J* = 1.7 Hz), 6.71 (dd, 2H, *J* = 7.6, 1.7 Hz), 6.55 (d, 2H, *J* = 7.9 Hz), 4.12 (ddd, 2H, 12.7, 10.0, 1.5 Hz), 3.90 (s, 6H), 3.21-3.11 (m, 4H), 2.83 (ddd, 2H, *J* = 12.9, 10.1, 7.4 Hz); ^{13}C NMR (150 MHz, $CDCl_3$) δ 167.1, 142.5, 140.3, 136.3, 136.0, 133.5, 130.4, 51.6, 35.8, 34.2; MS (DART) *m*/*z* 325 (100.0, M^++1); HRMS calcd for $C_{20}H_{21}O_4$: 325.1440, found 325.1431.

(S_p)-(+)-4,12-Bis(2-oxazolinyl)[2.2]paracyclophane ((S_p)-10).

To a solution of (S_p)-**SI3** (15.0 mg, 0.0463 mmol) in MeOH (0.25 mL) and THF (0.25 mL) was added aqueous solution of 40% NaOH (1 mL) at room temperature. After stirring for 6 h at 80 ºC, the reaction mixture was cooled to room temperature, acidified with aqueous solution of 10% HCl, and extracted with AcOEt-THF (10:1). The extract was washed with brine, dried and concentrated to dryness to afford the crude carboxylic acid (17.2 mg, quant.) as a colorless solid; $[\alpha]_D^{20}$ -36.2 (*c* 0.1, EtOH); ^1H NMR (400 MHz, methanol-*d*4): δ 7.20 (s, 2H), 6.75 (d, 2H, *J* = 6.9 Hz), 6.59 (d, 2H, *J* = 7.6 Hz), 4.09 (t, 2H, *J* = 10.7 Hz), 3.19-3.10 (m, 4H), 2.85-2.80 (m, 2H).

To the above carboxylic acid (17.2 mg, 0.0580 mmol) was added $SOCl_2$ (0.5 mL) at room temperature. After stirring for 15 h at 50 ºC, the volatiles were evaporated. The residue was dissolved in CH_2Cl_2 (0.4 mL) and added in dropwise manner to a solution of ethanolamine (0.1 mL) in CH_2Cl_2 (0.4 mL) at 0 ºC. The reaction mixture was stirred for 1 h at room temperature, diluted with water, and extracted with CH_2Cl_2-THF (5:1). The extract was washed with water and brine, dried and concentrated to dryness to afford the crude amide (25.8 mg, quant.) as an orange oil; ^1H NMR (400 MHz, $CDCl_3$): δ 7.88 (s, 2H), 6.84 (s, 2H), 6.64-6.58 (m, 4H), 3.85 (s, 4H), 3.75-3.50 (m, 8H), 3.14-3.09 (m, 2H), 2.90-2.77 (m, 4H).

To the above amide (25.3 mg, 0.0662 mmol) was added $SOCl_2$ (0.5 mL) at room

temperature. After stirring for 20 min at the same temperature, Et_2O was added to the mixture, which was basified with aqueous solution of 20% NaOH at 0 ºC, and extracted with AcOEt. The extract was washed with water and brine, dried and concentrated to dryness. The residue was dissolved in THF (1 mL) and NaH (60% dispersion of mineral oil) was added to the mixture at room temperature until chloro derivative disappeared (monitored by TLC). The precipitate was filtered and filtrate was concentrated to dryness. The residue was chromatographed with AcOEt and treated with decolorizing charcoal to afford (S_p)-**10** (7.8 mg, 34%) as a colorless solid; Mp 173-175 ºC (decomp.); $[\alpha]_D^{20}$ +49.5 (*c* 0.39, $CHCl_3$); IR 1636 cm^{-1}; ^1H NMR (600 MHz, $CDCl_3$): δ 7.12 (d, 2H, *J* = 2.1 Hz), 6.63 (dd, 2H, *J* = 7.9, 1.7 Hz), 6.54 (d, 2H, *J* = 7.9 Hz), 4.39-4.32 (m, 4H), 4.28-4.24 (m, 2H), 4.18 (dt, 2H, *J* = 13.7, 9.2 Hz), 4.08-4.03 (m, 2H), 3.16-3.10 (m, 4H), 2.84-2.79 (m, 2H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 164.3, 140.8, 140.0, 135.7, 134.8, 132.6, 128.0, 66.4, 55.5, 35.8, 33.9; MS (DART) *m*/*z* 347 (100.0, M^++1); HRMS calcd for $C_{22}H_{23}N_2O_2$: 347.1760, found 347.1765.

Typical procedure for asymmetric EtOH insertion reaction of 16 (Table 1, entry 5). (*S*)-(+)-Methyl 2-ethoxy-2-phenylacetate (17).[10]

To a suspension of (S_p)-**6b** (7.8 mg, 0.012 mmol) and MS5A (300 mg) in CH_2Cl_2 (1 mL) were added $NaBAr_F$ (10.6 mg, 0.0120 mmol) and $Cu(OTf)_2$ (3.6 mg, 0.010 mmol) at room temperature under an argon atmosphere. After being stirred for 4 h at the same temperature, EtOH (56 μL, 1.0 mmol) and then a solution of **16** (35 mg, 0.20 mmol) in CH_2Cl_2 (1 mL) were added to the reaction mixture at 40 ºC. The mixture was stirred at the same temperature for 1.5 h and filtered, and filtrate was concentrated to dryness. The residue was chromatographed with hexane-Et_2O (20:1) to afford **17** (34.1 mg, 86%) as a colorless oil; $[\alpha]_D^{23}$ +65.6 (*c* 0.86, CH_2Cl_2) {lit.,[10] $[\alpha]_D^{20}$ –85.7 (*c* 1.60, CH_2Cl_2) for -95% ee}; ^1H NMR (600 MHz, $CDCl_3$): δ 7.45 (d, 2H, *J* = 7.6 Hz), 7.37-7.31 (m, 3H), 4.89 (s, 1H), 3.71 (s, 3H), 3.62-3.57 (m, 1H), 3.53-3.48 (m, 1H), 1.27 (t, 3H, *J* = 7.0 Hz); ^{13}C NMR (150 MHz, $CDCl_3$) δ 171.4, 136.6, 128.6, 128.6, 127.1, 80.8, 65.3, 52.2, 15.1; 76% ee; HPLC: OD-H column; λ = 254 nm; eluent: hexane/isopropanol = 99.5/0.5; Flow rate: 1.0 mL/min; t_R = 11.6 min for (*R*)-enantiomer, t_R = 9.9 min for (*S*)-enantiomer.

Typical procedure for asymmetric intramolecular insertion reaction of 18 (Table 2, entry 1). (-)-Benzyl tetrahydro-2*H*-pyran-2-carboxylate (19).[3]

To a suspension of (S_p)-**6b** (7.7 mg, 0.012 mmol) and MS5A (300 mg) in CH_2Cl_2 (1 mL) were added $NaBAr_F$ (10.6 mg, 0.012 mmol) and $Cu(OTf)_2$ (3.56 mg, 0.00987 mmol) at room temperature under an argon atmosphere. After stirring for 4 h at the same temperature, a solution of **18** (44.5 mg, 0.179 mmol) in CH_2Cl_2 (1 mL) was added to the mixture at -78 ºC. The reaction mixture was warmed to room temperature and stirred for 4.5 h. The mixture was filtered and filtrate was concentrated to dryness. The residue was chromatographed with hexane-CH_2Cl_2 (1:4) to afford **19** (25.0 mg, 63%) as a colorless oil; $[\alpha]_D^{27}$ -11.9 (*c* 0.90, CH_2Cl_2) {lit.,[3] $[\alpha]_D^{20}$ +17.1 (*c* 1.73, CH_2Cl_2) for -93% ee}; ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.36–7.31 (m, 5H), 5.20 (s, 2H), 4.11–4.08 (m, 1H), 4.04 (dd, 1H, *J* = 10.7, 2.7 Hz), 3.50 (td, 1H, *J* = 11.4, 2.3Hz), 1.97–1.94 (m, 1H), 1.89–1.84 (m, 1H), 1.68–1.52 (m, 4H); ^{13}C NMR (150 MHz, $CDCl_3$): δ 171.5, 135.6, 128.5, 128.3, 128.3, 76.2, 68.1, 66.5, 28.8, 25.2, 22.8; 61% ee; HPLC: AS-H column; λ = 254 nm; eluent: hexane/isopropanol = 97/3; Flow rate: 1.0 mL/min; t_R = 11.8 min for major isomer, t_R = 15.3 min for minor isomer.

Typical procedure for asymmetric PhOH insertion reaction of 20 (Table 3, entry 3). (*S*)-(-)-Ethyl 2-phenoxypropionate (21).[11]

To a suspension of (S_p)-**6e** (7.3 mg, 0.013 mmol) and MS5A (315 mg) in CH_2Cl_2 (1 mL) were added $NaBAr_F$ (11.2 mg, 0.0126 mmol) and CuCl (1.0 mg, 0.010 mmol) at room temperature under an argon atmosphere. After stirring for 4 h at the same temperature, a solution of PhOH (98.8 mg, 1.05 mmol) in CH_2Cl_2 (0.5 mL) was added to the mixture. After 20 min, a solution of **20** (28.0 mg, 0.210 mmol) in CH_2Cl_2 (0.6 mL) was added to the mixture, which was stirred at room temperature for 1 h. The mixture was filtered and filtrate was concentrated to dryness. The residue was chromatographed with hexane-AcOEt (30:1) to afford **21** (28.0 mg, 66%) as a colorless oil; $[\alpha]_D^{23}$ -37.5 (*c* 0.43, MeOH) {lit.,[12] $[\alpha]_D^{18}$ +47.2 (*c* 0.5, MeOH) for -99% ee}; ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.29-7.25 (m, 2H), 6.98-6.95 (m, 1H), 6.89-6.87 (m, 2H), 4.74 (q, 1H, *J* = 6.9 Hz), 4.22 (q, 2H, *J* = 7.1 Hz), 1.62 (d, 3H, *J* = 6.9 Hz), 1.25 (t, 3H, *J* = 7.2 Hz); ^{13}C NMR (150 MHz, $CDCl_3$) δ 172.3, 157.6, 129.5, 121.5, 115.1, 72.6, 61.2, 18.6, 14.1; 80% ee; HPLC: OD-H column; λ = 254 nm; eluent: hexane/isopropanol = 9/1; Flow rate: 1.0 mL/min; t_R = 8.8 min for (*R*)-enantiomer, t_R = 4.9 min for (*S*)-enantiomer.

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